OF ~~MICE~~ MOTHS AND ~~MEN~~ MACHINES

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ABSTRACT: In 1947, Grace Murray Hopper a pioneer in early computing made an unusual entry into her daily logbook: 'Relay #70 Panel F (moth) in relay. First actual case of bug being found.' Accompanying this entry is an actual celluloid tape encrusted bug, or more specifically a moth, fastened to the page of the logbook. According to Hopper, one of the technicians in her team solved a glitch in the *Harvard Mark II* computer by pulling an actual insect out from between the contacts of one of its relays. Word soon went out that they had 'debugged the machine' and the phrase quickly entered our lexicon. After languishing for years this mythic moth was eventually transported to the *Smithsonian* where it now lies in archival state. The moth's dynamic vitality had introduced a kind of surplus or aberrant code into the machine, which in effect pushed the machine towards a state of chaos and breakdown. Its failure to act as desired, to perform the coding sequences of its programmed history suggests that even a seemingly inert or lifeless machine can become 'more and other than its history'. (Elizabeth Grosz, 2005) Hopper's bug is thus a material witness to the creative co-evolution of the machine with the living matter of the moth. Moreover, as a cipher for machinic defect the bug reminds us that mutations are in fact necessary for systems to change and evolve. The crisis introduced into a biological system or machine through the virulence of the bug is terminal only to the extent that it becomes the source for another kind of order, another kind of interaction. This is used as a case study to argue that chaos is not only an animating force in the constitution of new systems but is necessary for the evolution of difference.

KEYWORDS: Bug; Machine; Code; Archive; Evolution; Vitalism

> In vain we force the living into this or that one of our molds. All the molds crack, they are too narrow, above all too rigid, for what we try to put into them. Our reasoning so sure of itself among things inert, feels ill at ease on this new ground.[1]
>
> Henri Bergson, 1911

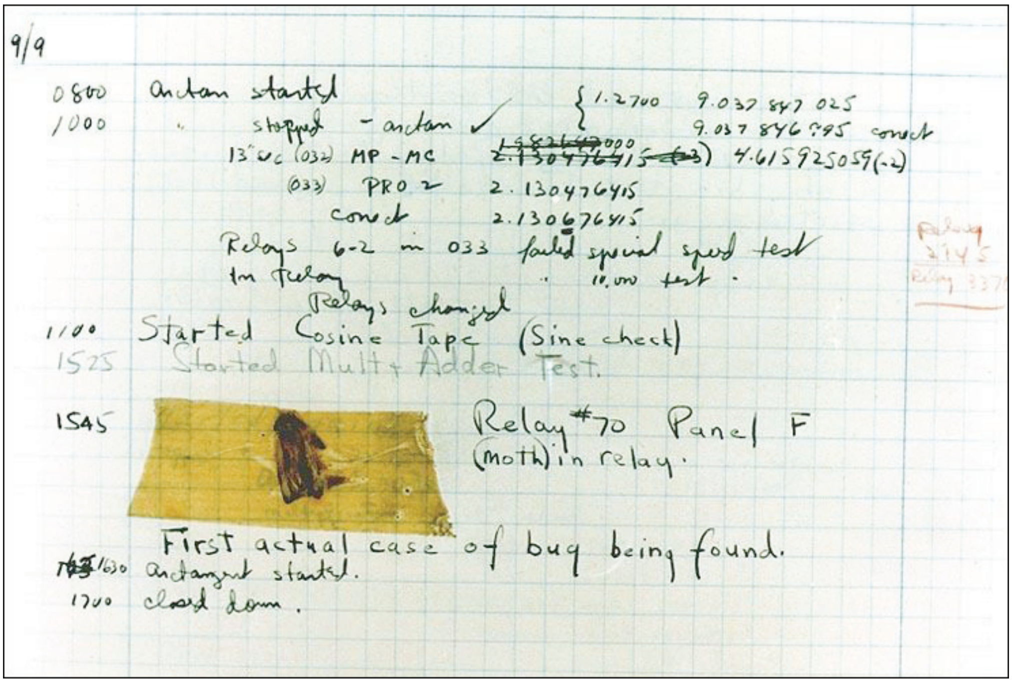
PART 1

On September 9th 1947 Grace Murray Hopper, a pioneer in early computing and inventor of the high-level programming language COBOL (**CO**mmon **B**usiness

1. Henri Bergson, *Creative Evolution*, trans. Arthur Mitchell, Mineola, Dover Publications, Inc., 1998. P. X.

Oriented **L**anguage), made an unusual entry into her daily logbook:

15:45 (3:45pm)	Relay #70 Panel F (moth) in relay. First actual case of bug being found.



Grace Hopper's Logbook. Smithsonian Photo # NH 96566-KN

Accompanying this brief entry is an actual celluloid tape-encrusted bug, or more specifically—a moth—fastened to the page of the logbook. According to Hopper, one of the technicians in her team solved a glitch in the Harvard Mark II machine (an electromechanical computer used by the US Navy for gunnery and ballistic calculations) by pulling an actual insect out from between the contacts of one of its relays with a pair of tweezers. Word soon went out that they had 'debugged' the machine and the phrase 'debugging a computer' entered our lexicon.[2] Although Grace Hopper was always careful to admit that she was not in the room when the bug was retrieved. After languishing for years in a state of ignominious display at the Naval Surface Warfare Center Computer Museum in Dahlgren, Virginia this mythic moth was transported to the Smithsonian in 1991 where it now lies in archival state.[3]

2. According to the *OED Supplement* and *The Journal of the Royal Aeronautical Society*, the term 'debug' had already been in use within engineering slang since 1945 although Hopper's team did originate the phrase 'debugging a computer'.

3. Hopper's bug is archived in the *History of American Technology Museum, which* is part of the *Smithsonian* museum complex.

While this inaugural sighting of a real bug in the machine has circulated widely within computing lore, the etymological history of the term bug actually predates this particular incident, something Grace Hopper herself was clearly aware of given the syntax of her notation 'first *actual* case of bug being found' [emphasis added]. Her wording suggests that the term bug with its connotations of apparatus defect was already in use, something she later acknowledged in confirming that the word bug was regularly applied to problems in WWII radar technology. Given this extant genealogy Hopper and her colleagues must have regarded the discovery of the moth with certain astonishment since mechanical defects were already called bugs.[4]

The 'living' to which Henri Bergson refers in the opening citation had inadvertently entered into the Harvard Mark II computer causing a computational glitch or crack in its machinic mold as its fluttering gesticulations interfered with the transmissional regimes of its relays. The moth's dynamic vitality introduced a kind of surplus or aberrant code into the machine, which in effect pushed the machine towards a state of chaos and breakdown. Its failure to act as desired, to perform the coding sequences of its programmed history suggests that even the mechanistic life of the machine can 'exceed itself, its past, its context, in making itself more and other than its history.'[5] Grace Hopper's diminutive invader testifies to the fragile ecosystem of the machine as a set of relational forces whose equilibrium is easily disturbed by nano-events of chance. Echoing Bergson's prophetic statement, the accidental commingling of nonorganic matter with the living matter of the moth not only transformed the machine but also inaugurated its estrangement to its own machinic genotype—its glitch no doubt causing some anxiety for the Hopper team as they intervened in an attempt to return it to a state of normalcy. 'Our reasoning so sure of itself among things inert, feels ill at ease on this new ground.'

The moth in refusing to conform to the principles of a closed system embeds it vital materiality with the circuitry of the computer releasing a new machine, which even in a state of complete system failure becomes an index of its potential to change, to become other. In transgressing the limits of its original systematicity, the machine overturns its state of inertia and remakes itself, bringing another version of events into being. 'Events are always unique and unrepeatable configurations of things and processes that exert widespread, uncontainable effects on a prevailing system.'[6]

Unlike contemporary data processing machines, the Harvard Mark II was not a stored-program computer but read and executed instructions from a tape. This separation of data and instructions (known as Harvard architecture) further emphasizes the intercession carried out by the moth, which in effect introduced another set of programmed instructions into the machine. Unable to read the patterns encoded on the wing tips of the moth—the machine crashed. Although the Harvard Mark II broke down due to the moth's interference in one of its relays, the idea of an insect introduc-

4. Fred R. Shapiro, 'Etymology of the Computer Bug: History and Folklore', *American Speech*, vol. 62, no. 4, 1987. P. 377.
5. Elizabeth Grosz, *Time Travels: Feminism, Nature, Power*, London, Duke University Press, 2005. P. 40.
6. Ibid. P. 38.

ing a deviant coding sequence into the machine's operations is not as far fetched as it may at first appear. Early computers functioned entirely as information processors and data was fed into them via perforated tape or cards made out of cellulose. This material, which derives from the cell walls of plants and algae, naturally attracted numerous insects and their larvae. 'These bugs would attack the data storage media leaving additional perforations to be read by the processing equipment. As a result the data was rendered useless due to the voracious appetites of the bugs.'[7]

The insertion of anomalous perforations into the tape by these rapacious insects initiates a radical recoding of the machine, which in turn deterritorializes it, creating another kind of machine. Hopper's bug is thus a material witness to the creative co-evolution of the machine and moth as they enter into a strangely symbiotic relationship or machinic assemblage in which each effectuates the other in its form and substance. As Deleuze & Guattari stress the assemblage organizes matter and form into new relations: matter ceases to be a question of content, becoming instead a matter of expression. Form ceases to be a code subduing the forces of chaos, becoming instead a force itself.[8] The Harvard Mark II plugs into the 'territorial assemblage of the species—moth—and opens it to other assemblages, causes it to pass through the interassemblages of that species as well as the interspecific assemblages of all bugs and computer viruses.'[9]

Moreover, as a cipher for machinic defect the bug reminds us that mutations are in fact necessary for systems to change and evolve. The crisis introduced into a biological system or machine through the virulence of the bug is terminal only to the extent that it becomes the source for another kind of order, another kind of interaction. Rather than destroying order it creates something new. According to Warren Weaver who co-authored *The Mathematical Theory of Communication* with Claude E. Shannon in 1948, mutations in the transmission of the message are not antagonistic but crucial for systems to evolve in new directions.[10] 'Mutations normally occur when some random event (for example, a burst of radiation or a coding error) disrupts an existing pattern and something else is put in its place instead.'[11] Information depends upon both predictability and unpredictably, pattern and randomness. 'The randomness to which the mutation testifies is implicit in the very idea of pattern, for only against the background of non-pattern [or noise] can pattern [and legibility] emerge.'[12] The idea that chaos is not only an animating force in the constitution of new systems but is necessary for the evolution of difference will prove crucial to an understanding of this particular animal-ma-

7. Nigel Rawlins, *IT Myths: Buggin' out - the history of a word we all hate*
, silicon.com, 2003. Accessed July 13 2006, Available from http://management.silicon.com/smedirector/0,39024679,10005407,00.html.

8. Gilles Deleuze and Félix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, trans. Brian Massumi, London, Continuum, 1988. P. 340.

9. Paraphrased from Ibid. P. 333.

10. Claude E. Shannon and Warren Weaver, *The Mathematical Theory of Communication*, Urbana, University of Illinois Press, 1948.

11. N. Katherine Hayles, *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*, Chicago, University of Chicago Press, 1999. Pp. 32-33.

12. Ibid. P. 33.

chine encounter. Viral infections whether chemical or informational begin to blur the boundaries between 'what is regarded as inorganic and what has an organic-like life of its own.'[13] For example, genetic algorithms of the kind used in the generation of a-life sequences are reliant upon the tendency of self-replicating computer code to produce variations or mutations in their coding chains over time which in turn have the capacity to evolve new a-life forms. In a strange twist of fate the Hopper bug anticipates these developments in a-life computing, however unlike the Hopper moth these a-life bugs are no longer regarded as intruders that must eradicated. The mutant is now welcomed into the system as a force of evolutionary change and understood as *necessary* to the system's ongoing survival.

PART II

Not only does the Hopper bug collapse the distinction between the biological and informational body but also that between materiality and discourse. Tracing the genealogy of the term bug reveals that a similar ontological ambiguity prevailed between its entomology and etymology within early accounts of such technological defects. The *OED Supplement* states that the noun bug signifying a defect or fault in a machine has been in circulation since 1889. On March 11th of that year the *Pall Mall Gazette* reported that 'Mr. Edison. . . had been up the two previous nights discovering a 'bug' in his phonograph—an expression for solving a difficulty, and implying that some imaginary insect has secreted itself inside and is causing all the trouble'.[14] In an even earlier letter to Theodore Puskas, dated November 18, 1878, Thomas Edison wrote:

> 'It has been just so in all my inventions. The first step is an intuition—and comes with a burst, *then* difficulties arise. This thing gives out and then that—'Bugs'—as such little faults and difficulties are called—show themselves and months of anxious watching, study and labor are requisite before commercial success—or failure is certainly reached.'[15]

An online forum dedicated to computer jargon maps out an even more detailed history of the term bug suggesting that it had already been well-established in the mid 19th century as an expression connoting industrial defect within the emergent fields of electricity and telegraphy, both of which Edison would have been intimately acquainted with. An electrical handbook from 1896, *Hawkins's New Catechism of Electricity* notes, 'the term 'bug' is used to a limited extent to designate any fault or trouble in the connections or working of electric apparatus.'[16] Although its meaning is said to have originated in quadruplex telegraphy it migrated rapidly to include all glitches in electrical transmission. Noisy telephone reception was inked to 'bugs in its cables', an expression that forwards an image of legions of tiny insects scurrying through phone lines causing signal

13. Elizabeth Grosz (ed.), *Thinking the New: Of Futures Yet Unthought*, Ithaca, Cornell University Press, 1999. P. 23.
14. Shapiro, 'Etymology of the Computer Bug: History and Folklore'. P. 377.
15. Citation discovered by John Lord, who published his finding in *Byte* magazine (July 1984: 32).
16. Mathew Josephson, *Edison*, New York, McGraw-Hill, 1959. P. 198.

interference. The bug in this 19^{th} context was understood simultaneously as a physical specimen and means of metaphoric description.

Historians in the field of telecommunications note that the word bug also appeared within the domain of early telegraphy in reference to the intricate use of semi-automatic telegraphy keyers or bugs to send out a sequence of dots. The length of this chain of dots and subsequent coherency of its message when decoded was entirely dependent upon how long each key was held down. Holding a key for fraction too long caused extraneous dots to enter into the coding string, producing a garbled message or noise. The most common keyer, the *Vibroplex* semi-automatic invented by Horace G. Martin in 1905 even had a graphic image of a beetle incised on it, a logo the company still uses today. Thus an inexperienced Morse-code operator, used to the older manual keyers, might inadvertently introduce what was called a *Vibroplex Bug* into the sequence or line.[17]

Further notations on the jargon website point out that the term bug has also been used to describe a machine that traces radio interference by converting electromagnetic field variations into acoustic signals. The labelling of this device as a bug by the radio community derives from the roach-like shape of its earliest versions which consisted of a coil of wire or roach body, with two protruding wire ends nearly touching to form a spark gap—or roach antennae. This bug functioned as a kind of atmospheric stethoscope for monitoring the externalized contamination of the radio communication network by viral or errant signals. In essence, a bug for tracking other bugs.

Outside of the realm of computing and general systems failure the bug has of course also proliferated within legal and juridical domains in reference to wiring tapping, surveillance, and all manner of covert-monitoring devices. With respect to these invasive electronic operations the word bug seems permanently and semantically estranged from its initial insinuation into a machinic system as vibrating organic matter. Rarely does the word bug refer to insects anymore as it did in the early days of telephonic and telegraphic experimentation. Grace Hopper's moth is therefore not so much an uncanny case of life imitating fiction, that is, an entomological articulation of its own textual etymology, but rather a trans-historical marker indicating that the dynamism of the machine is neither wholly discursive, nor simply motionless matter subject to external forces of transformation. The conditional state of the Harvard Mark II was made explicit by the incursive event of the moth that entered its internal machinic organs, and caused them to fail. So much so, that to consign the breakdown of the machine to a conceptual turn of phrase negates its capacity to be as profoundly affected by the movements of chance as any living organism.

PART III

Classic vitalism as a philosophical doctrine posits that the emergence of living organisms cannot be fully explained by mechanical, biological or chemical processes but

17. Paraphrased from Anon., *The Jargon File: bug*, Version 4.4.7, The Jargon File, 2006. Accessed June 21 2006, Available from http://catb.org/esr/jargon/html/B/bug.html.

requires something more—an élan vital or spark of life (soul) that brings it into being. Nineteenth century biology, according to Michel Foucault, conceptualised this mysterious life force as the 'sovereign vanishing point within the organism'. Contrary to classical vitalism, Hopper's moth did not contain its animating force exclusively within, that is to say for and by itself. Instead it made available its vitality, distributing its affects through the Harvard Mark II which in turn sparked the machine into performing another state of computational action, albeit that of the portentous mortality of the glitch. While the components of the Harvard Mark II were ultimately re-vivified through the removal of the small organic body hosting on one of its relays, the machine didn't necessarily return to its previous state. System failure disrupts the fantasy of an undifferentiated eternal return, given that any new account of the machine must now also include the fact of its encounter with alien matter. In a peculiar form of zombification the machine was resurrected from the dead to assume another 'life form' through the extraction of the very living being that had previously consigned the machine to a state of mere mechanistic determination or inertia within both philosophic and scientific debates.

Classical accounts of vitalism require the intercession of the soul to render organic matter lively and since like zombies, machines have no souls (allowing us to kill them without impunity), the machine has historically occupied the hinterlands of the dead-zone. In the first volume of *Capital*, Karl Marx launches a vitriolic and detailed attack upon the machines of the Industrial Revolution, specifically those forms of mechanization that led to dramatic shifts in the means and relations of production for the worker. These one-eyed machines or monstrous Cyclops as Marx referred to them reduced the worker to simply another repetitive cog in the mechanisms of capitalism.

> "The worker's activity. . . is determined and regulated on all sides by the movement of the machinery, not the other way round. The knowledge [*Wissenshaft*] that compels the inanimate part of the machine into action as an automaton in accordance with their construction does not exist in the consciousness of the worker, but rather acts upon him through the machine as an alien force, as the force of the machine itself."[18]

This passage suggests that the machine has become an autonomous agent with literally supernatural powers, one that has invaded the body, cancelling its free will and conscious self-determination.[19] Industrialised modes of production contends Marx, depose the sovereignty of the human, supplanting its agency with the instrumental functions of mechanisation. The vital forces that once flowed through the body of the worker seem to have been re-routed through the operations of the machine into the circulatory system of capital. 'Our machines [notes Donna Haraway] are disturbingly lively, and we ourselves frighteningly inert.'[20] Much more than an orchestration of mechanis-

18. Karl Marx, *The Grundrisse*, trans. D. McLellan, D. McLellan (ed.), New York, Harper and Row, 1971. P. 133.

19. See Mark Hansen's discussion of Karl Marx's *The Grundrise* in Mark Hansen, *Embodying Technesis: Technology Beyond Writing*, N. Katherine Hayles (ed.), Ann Arbor, University of Michigan Press, 2000. P. 218.

20. Donna Jeanne Haraway, *Simians, Cyborgs, and Women: The Re-invention of Nature*, London, Free

tic components producing a dissonant relationship between the body and the machine, Marx intuits a kind of convergence in which the rhythms of the machine move through and occupy the body blurring boundary distinctions, even if at the time of his writing Marx theorizes capitalism as initiating a complete subsumption of the worker's body to the machine. Our commitment to conceiving of mechanism and vitalism as two expressions of the same machinic state can thus be said to finds it's footing already within the modalities of the 19th century. Pulling the plug on a machine is therefore not a simple matter, nor without its ethical implications as is testified to the by the multiple and integrated life-support systems that bring men and machines into coterminous states with each other.

The lifeless vitality of Hopper's insect intruder continues to haunt the collective history of the machine even while consigned to the archives of the *Smithsonian*. In fact the vectors that connect its expressive intensities across time and space might be even more resonant now as the mythic dimensions of its historic machinic infestation continue to accumulate. If life or vitality has traditionally been understood as exclusive to the process-oriented modes of individuation associated with organisms, then the invention of a new vitalism, one capable of addressing the animation of non-organic matter—the machine—finds expressive potential in the complex genealogy of the bug as both embodied matter and an articulating force that can radically alter the previous state of a system or machine. This is a story of unnatural selection or creative evolution, a story in which the spatio-temporal dynamisms of materiality—carbon or silicon—can only be experienced processionally through the shifting relations between objects and events. Material processes only become dynamic when they make a commitment to probing the limits of what it means to say that something is alive. In their article "Inventive Life: Approaches to the New Vitalism" the authors argue that an advantage of such process thinking is 'that the co-ordinates of space and time are not understood to be external to (relations between entities). Change, that is, does not occur *in* time and space. Instead, time and space change according to the specificity of an event.'[21] In short it is 'the event makes the difference: not in space and time, but to space and time.'[22]

PART IV

Grace Hopper's insect wasn't just any bug, but a moth, a creature of now legendary infamy within the history of evolution itself. It is no small coincidence that the very peppered moths that were used to exemplify Darwin's theory of natural selection within evolutionary science during the 1950s was of the same species as Hopper's own interlocutor.

During the forties and fifties, self-taught biologist H.B.D. Kettlewell under the tutelage of geneticist E.B. Ford of Oxford University set out to find the crucial missing

Association, 1991. P. 153.

21. Mariam Fraser, Sarah Kember and Celia Lury, 'Inventive Life: Approaches to the New Vitalism', *Theory, Culture & Society*, vol. 22, no. 1, 2005a. P.4.

22. Mariam Fraser, Sarah Kember and Celia Lury. Ibid., pp. 1-14. P.4.

evidence to support Darwin's evolutionary theory.[23] As a lepidopterist specialising in moths, Kettlewell naturally turned to his nocturnal companions for inspiration in conducting his experimental research. In the now notorious case of the peppered moth they (Kettlewell and Ford) argued that variations in wing colouring were directly linked to species-preservation through a process of self-induced pigmentation, which allowed for greater camouflage (or crypsis) against predators and could therefore account for a proportionate increase or decrease in moth populations. Kettlewell claimed a higher survival rate for moths that had developed a form industrial melanism (blackened wing-tip patterns) via selective breeding patterns in coal producing industrial regions of England over their lighter-coloured predecessors who were in state of population decline. This factor was attributed to the greater visibility of normal or non-melanic moths to avian predators when resting upon soot-stained tree bark and lichen. Conversely in less polluted rural woodland regions Kettlewell documented an inversion in melanic moth populations. These famous experiments soon became the most dramatic examples of natural selection in action refuting competing theories of species adaptation and random drift.

Inculcated into biology curriculums worldwide, the case of the peppered moth reigned supreme until doubts began to surface as early as 1975 when Kettlewell's former assistants Robert Creed and David Lees failed to repeat his legendary experiments.[24] Their work in East Anglia and Birmingham raised serious questions as to the methodology and findings obtained by Kettlewell under Ford's tutelage. Kauri Mikkola, a young Finnish scientist at the University of Helsinki, had also conducted observational research in the late 1970s that fundamentally contradicted aspects of Kettlewell's theory, namely that moths did not rest on the exposed bark of tress but rather on the underside of lateral branches, something that Kettlewell himself had already observed in writing about the microhabitats of moths but later contradicted in "Darwin's Missing Evidence" his landmark 1959 article published in *Scientific American*. Although scientists in Britain had been trying unsuccessfully to achieve results that paralleled those of Kettlewell since the mid-sixties, another twenty years would pass before the case was incontrovertibly contested.

In his book *Melanism: Evolution in Action* (1989), Cambridge researcher Michael E.N. Majerus asserted that we must dismiss industrial melanism in Biston Betularia (peppered moths) as an exemplar of natural selection but that the basic tenets of ecological genetics and evolution forwarded by Kettlewell and Ford still stood firm. Ultimately it would fall to Ted Sargent, emeritus professor of biology at the University of Massachusetts, Amherst to strike the final body blow to the case of the peppered moth. In 2002 upon close observation of Kettlewell's documentary photographs, Sargent noted that the images were faked, that is, the moths in question were already dead due to the attenuation of their antennae. Moths in a resting position retract their antennae and

23. Charles Darwin never actually used the term evolution but called his theory 'descent with modification'.

24. Judith Hooper, *Of Moths and Men: The Untold Story of Science and the Peppered Moth*, New York, W.W. Norton Company Inc., 2002. P. 355.

conceal them under their forewings. Sargent also found serious errors as to the experiment's methodology and statistical analysis through a re-examination of Kettlewell's evidentiary papers and research results. For example, the number of moths that were set out on the trees far exceeded the normal population levels found in the environments of Dorset and Birmingham where Kettlewell had originally conducted his experiments. Kettlewell, he argued, had effectively created a sumptuous bird feeder but not a falsifiable scientific experiment. Today the changes in the moth's wing colouration and its population variation remains causally indeterminate; perhaps a response to increased levels of sulphur dioxide emissions during times of pollution or the consequence of random mutational forces and coding anomalies within its genotype. Or perhaps they are even attributable to epigenetic changes that are not linked to alterations in its DNA sequencing but are the results of successive differentiations from the substance of its embryo. Industrial melanism in moths is not the outcome of a process of self-selective breeding in response to the changing visual template of an organism's habitat. In fact the occurrence of melanic and normal moths did not vary greatly between industrial and rural areas. Kettlewell's population samples were exceedingly limited, so much so, that he had to intervene actively in the recruiting and recapturing his moths.

> 'If Kettlewell hadn't been so convinced of the truth of bird predation affecting peppered moth evolution, he might have left more room for alternative explanations. . . When scientists have, as Lynn Margulis puts it in *Slanted Truths*, 'an uncritical acceptance of the mesmerizing concept of adaptation,' there is a real danger of seeing what one believes.'[25]

Although the peppered moth has since relinquished its status as *the* archetype of natural selection, it still remains permanently pinned to the pages of evolutionary history. With its ascension into the archives of the Smithsonian, Hopper's moth too has attained near immortality within the history of technology. Yet it is only an act of imaginary retrospection that can reinvent the flights paths travelled by these moths as they land with such prescience within the present pages of this text. In a sense our critical work is to pull these moths out of time, in a gesture not entirely unrelated to the action of Hopper's technician as he carefully teased the errant moth out of the Harvard Mark II and into popular computer mythology. An extraction in which the object or organism's future is not predetermined by its past 'is not limited by what it was, by its form, and its history' but remains open to the dynamism of time. As Elizabeth Grosz writes in *Time Travels* to reflect upon an object or organism's history, is to mobilise it past life in terms of its forces and abilities to act in the present, which in turn transform contingent experiences into other histories or other paths of development.[26] In essence activating it's potential to be otherwise.

25. Craig Holdrege, 'The Case of the Peppered Moth Illusion', *Whole Earth*, Point Foundation, 1999. Cited by Hooper, *Of Moths and Men: The Untold Story of Science and the Peppered Moth*. P. 298.

26. See *Grosz, Time Travels: Feminism, Nature, Power*. P. 40.

PART V

The delicate body of the moth is thus an evolved sign of conjunctive contingency folded between the open-ended becoming of organic life and the modulating operations of non-organic matter. According to Keith Ansell Pearson, one of Deleuze & Guattari's most radical ideas is their suggestion that evolution in its purely biological formulation has never actually existed since evolution is nothing but technics, an operation of machinic assemblage which brings heterogeneous bodies, objects, and events from across biological, social and/or economic domains into indeterminate contact with each other, producing what they call a mechanosphere.

> 'Becoming is not an evolution, at least not by descent and filiation. Becoming produces nothing by filiation; all filiation is imaginary. Becoming is always of a different order than filiation. It concerns alliance. If evolution includes any veritable becomings, it is in the domains of symbioses that bring into play beings of totally different scales and kingdoms, with no possible filiation.'[27]

The machinic assemblage to which Hopper's moth points is not simply a case of an *actual* bug trapped within a machine which would assume a dialogic relationship between vitalism and mechanism but rather an alliance between two radically different kinds of machines, two different systems with no possible filiation save one of creative involution. The moth is an embodied witness to just such an alliance: one of an emergent symbiosis between mechanical and vitalist accounts of life. Georges Canguilhem, French philosopher of science, suggests that we concern ourselves not with the dialectical processes of thought that move between vitalism and mechanism, but rather with the subject of its fascination—life itself. This is the dialectical essence that he argues our thinking needs to take into account.[28]

Deleuze & Guattari state that 'the real difference is not between the living and the machine, vitalism and mechanism, but between two states of the machine that are two states of the living as well. The machine taken in its structural unity, the living taken in its specific and even personal unity, are mass phenomena or molar aggregates; for this reason each points to the extrinsic experience of the other. . . But in the other more profound or intrinsic direction of multiplicities there is interpenetration, direct communication between the molecular phenomena and the singularities of the living, that is to say, between the small machines scattered in every [molar] machine, and the small formations dispersed in every organism: a domain of nondifference between the microphysical and the biological. . .'[29]

Classic vitalism is said to commit a 'philosophically inexcusable mistake when it takes the *originality* of life to mean that life constitutes an *exception* to the laws of the physical milieu.'[30] This view locates vitalism in opposition to normativity as that which cannot

27. Deleuze and Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*. P. 238.

28. See Georges Canguilhem, *La Connaissance de la Vie*, Paris, Vrin, 1975. P. 85.

29. Gilles Deleuze and Félix Guattari, *Anti-Oedipus: Capitalism and Schizophrenia*, trans. Robert Hurley, Mark Seem and Helen R. Lane, London, Continuum, 1984a. Pp. 285-86.

30. Canguilhem cited by Monica Greco, 'On the Vitality of Vitalism', *Theory, Culture & Society*, vol. 22, no.

be explained by rational means. Canguilhem calls this reactive thinking. 'It is not as an account of life that vitalism appears viable; rather, it is as a symptom of the specificity of life that its recurrence should be understood.'[31]

However in the life sciences today vitalism is still perceived as an untenable concept. Many biologists such as Richard Dawkins have heaped scorn upon vitalism, which they associate with 'lack of intellectual rigour, anti-scientific attitudes and superstition.'[32] From the perspective of molecular biology, DNA has been 'outed' as the secret force propelling life. Mystery solved, game over: 'that is all there is.'[33] The work of Canguilhem is extremely useful to our discussion because he conceives of vitalism as an 'ethical demand rather than a positive philosophy of life.'[34] Likewise Physicist Ilya Prigogine and Isabelle Stengers in their seminal collaborative work *Order Out of Chaos* (1984) posit that a renewed interest in vitalism could prove strategically relevant to current thinking in converging arenas of scientific experimentation. For our purposes today this must also include the domain of computing which itself points to the vitality of digitized or informatic life.

PART VI

In terms of cellular biology, a return to vitalism supports the idea that life is an emergent process that cannot be accurately or fully described through an understanding of the various chemical processes taking place in the cell. Richard Doyle displaces this view of life, one that locates its most enigmatic quality within the singularity of the organism, in his most recent book *Wetwares: Experiments in Postvital Living*. 'From the perspective of many contemporary biologists' he states 'life is just an interesting configuration of information.'[35] The definition of a living organism as a discrete organic entity is unseated by a reconfiguration of life as a networked system of information. Deleuze & Guattari's model of machinic assemblage (a system of interconnected parts that cut across fields of enunciation) provides Doyle with a conceptual roadmap for drafting his thesis of the postvital. 'Here vitality is no longer understood to inhere in the organism, but is rather a property brought about by informatic transfer, a result of communication within [and across] systems.'[36] In evacuating vitality from the hermeticism of the cell and organism Doyle is able to move beyond the claim that life is exhausted by the revelation of the genetic code within all living organisms.

When dynamism [life] is refigured as the flux of data transfer, 'life is no longer con-

1, 2005, pp. 15–27. P. 17.

31. Ibid. P. 18.

32. See Richard Dawkins, *The Blind Watchmaker*, London, Longman, 1988.

33. Richard Doyle, *On Beyond Living: Rhetorical Transformations of the Life Sciences*, Stanford, Stanford University Press, 1997. P. 19.

34. Greco, 'On the Vitality of Vitalism'. P. 15.

35. Richard Doyle, *Wetwares: Experiments in Postvital Living*, Sandra Buckley, Michael Hardt and Brian Massumi (eds.), Vol. 24, Minneapolis, University of Minnesota Press, 2002. P. 20.

36.Melanie Gilligan, *Postvital Signs*, 2004. Accessed April 6 2006, Available from http://www.metamute.org/en/trackback/6763.

fined to the operation of DNA but is instead linked to the informatic events associated with nucleic acid: operations of coding, replication, and mutation. . . the emergence of artificial life signals more than the liberation of living systems from carbon—it maps a transformation of the scientific concept of life itself, a shift from an understanding of organisms as *localized agents* to an articulation of living systems as *distributed events*.'[37]

Complexification 'inscribes the overarching questions of our era in a narrative frame that connects them to crises of matter and the genesis of life.'[38] Doyle's project poses a fundamental question in asking: what do we mean when we say something is alive. He makes the important observation that the 'very success of the informatic paradigm, in fields as diverse as molecular biology and ecology has paradoxically dislocated the very object [life] of biological research'.[39] Prigogine and Stengers make a similar point when they describe 'vitalist concepts as meaningful for biology within the broader scientific context characterized by Newtonian physics, but as having been made redundant by 20th century developments both in physics and in (molecular) biology.'[40]

While scientists may claim that vitalism is obsolete, Doyle asserts that traditional conceptions of life are themselves obsolete, thus the 'post' in postvital. Seemingly contrary to Prigogine and Stengers, the vital for Doyle, which he critiques in its classic formulation, can no longer adequately account for the machinic processes expressed through databases and networks—organisms as extensions of code. Does the postvital perform a rhetorical slight-of-hand in substituting the dynamism or vitality of organic life with the networked flow of zeros and ones? Doyle's larger research project has been to provide critical insight into the ways in which rhetorical programs or rhetorical softwares as he calls them shape scientific research trajectories. Most notable is his work on the appropriation of the metaphor of code by Watson and Crick to describe the structure of DNA. In developing his current thesis of the postvital he turns his posthuman eye towards the future: teasing out his argument from recent research in artificial life, cloning, cryonics, organ transplant, as well as from the domains of science fiction film and literature including tales of alien abduction. In refusing the vital because it's mysterious life force is historically bound to bygone notions of a coherent sovereign subject, Doyle finds the 'world of tomorrow' teeming with life. Although some of the technical practices he details are operational today, most must find their conceptual coordinates within the realm of the speculative. Doyle's postvitalism is a really a theory of future becomings. In an ironic [cryonic] sense, lives not yet lived, or a life in-wait of the kiss of technological revivification. Postvital or prevital? A discourse about life or a discursive life? His obvious commitment to rhetoric and literary analysis necessarily uproots his work from the ontological ground of materialism and plants it firmly within the soil of the discursive. The postvital in Doyle's case therefore cannot be located by way of opposition to the vital as his version of vitalism is clearly a difference in kind not degree.

37. Doyle, *Wetwares: Experiments in Postvital Living*. P. 18.
38. Isabelle Stengers, *Power and Invention: Situating Science*, trans. Paul Bains. Ibid., 1997a. P. 4.
39. Richard Doyle, *Wetwares: Experiments in Postvital Living*. Ibid., Vol. 24, 2002. P.20
40. Greco, 'On the Vitality of Vitalism'. P. 15.

If vitalism in its classic metaphysical mode is said to be aligned with processes of becoming or emergence, its re-distribution to digital events surely holds some potential to speak to the distributed agency of data itself; its deterritorialized and machinic becomings as viral/vital life. The move to reinvent vitalism because its classic iteration located it within the sovereignty of the organism must also problematize an account of the organism as a singularly unique entity disconnected from its structural coupling with all other elements in its environment. The organism's vitality needs to link with that of other vital systems if it is to survive. Cells speak to other cells within a living system; informatic code to other coding chains within a computational device. Doyle makes this very point in arguing that 'a distributed model of life—in which organisms are effects of acentered networks rather than privileged locations of vitality—foster the encounter with life which is something other than an 'essence' or sacred site of interiority.'[41] Vitalism becomes useful when, as Canguilhem states, we do not regard it as providing a narrative account of life but as 'a symptom of the specificity of life' in its vigorous materiality. Doyle needn't go beyond the vital towards the postvital to make his arguments; in fact a strategic reterritorialization of the term would do the productive work of unhinging it from its received understandings as entirely metaphysical. This operation would serve his purposes well. It might even allow him to re-situate his objects of study within a materialist ecology rather than a purely rhetorical or discursive one.

'The imperative to refute vitalism, in a sense, is superseded by the need to account for its permanent recurrence. The question of vitalism acquires a new dimension—a diachronic dimension—that supplements and subverts each of its settlements.'[42] Reading vitalism against the episteme of scientific rationalism towards ontology [an ontology of becoming], necessitates a conceptual manoeuvre that acknowledges the 'movement that links knowledge with its condition of possibility, life'.[43] Sociologist Monica Greco argues that 'not many authors acknowledge the semantic polyvalence of vitalism, and it is assumed that vitalism necessarily involves some reference to metaphysical principles, some degree of teleological thinking, and the opposition to mechanism.'[44]

Vitalism can be roughly divided into two categories: animist and naturalistic. The first version of vitalism is decidedly 'metaphysical and teleological in orientation, while the second posits organic natural laws that transgress the range of physical explanations.'[45] Canguilhem insists that the historical vitality of different versions of vitalism must be taken seriously, arguing that its dogged persistence and reappearance in the face of mechanism and information theory demands our critical attention. What is relevant about vitalist theories and concepts for Canguilhem and by extension for us is as Greco points out: not what they *say* and whether what they say can be scientifically

41. Doyle, *Wetwares: Experiments in Postvital Living*. P. 121.
42. Greco, 'On the Vitality of Vitalism'. P. 17.
43. Ibid. P. 18.
44. Ibid. P. 16.
45. Ibid. P. 17. See F. M. Wuketits, 'Organisms, Vital Forces, and Machines: Classical Controversies and the Contemporary Discussion "Holism vs. Reductionism"', in F. M. Wuketits and P. Hoyningen-Huene (eds.), *Reductionism and Systems Theory in the Life Sciences*, Dordrecht, Kluwer Academic Publishers, 1989.

validated—but rather what they *do*. . . Vitalism's status as a 'negative term of reference' against which biological inquiry has progressively distanced itself doesn't unsettle the fact, Canguilhem maintains, that vitalism 'represents a significant motor force in the history of biology'.[46]

Michel Foucault writes:

> 'if the 'scienticization' process is done by bringing to light physical and chemical mechanisms. . . it has on the other hand, been able to develop only insofar as the problem of the specificity of life and of the threshold it marks among all natural beings was continually thrown back as a challenge. This does not mean that 'vitalism'. . . is true. . . It simply means that it has had and undoubtedly still has an essential role as an 'indicator' in the history of biology.'[47]

Canguilhem and Foucault's reflections suggest that what is ultimately important isn't a recuperation of the historical vitality of vitalism in order to praise it, but to acknowledge its perspicacity to effect critical thinking vis-à-vis paradigms of life-studies today. Greco asks: are there other vantage points, in the landscape of contemporary scientific knowledge that might lead us to regard vitalism as a current form of thought? We would like to respond in the affirmative by referring to the domains of biomedia and systems biology wherein the question of vitality or life has already been recast as question of dynamic relations between events within an informatic system. Moreover, an ontology of vitalism may prove more useful still, as an ontology of becoming that can traverse force fields of knowledge beyond those of the life sciences.

PART VII

Accounts of machinic objects, within the landscape of media studies tend to be located along an dialectical axis alternating between mechanism, which is aligned with the analogue emphasizing concrete mechanical machine operations and vitalism which finds expressive potential in digital and immaterial processes. This notion, that media objects *naturally* structure their conceptual affiliation between the limits of mechanism and vitalism, is eschewed by this paper. Substituting one paradigm for another is unproductive unless we consider how they both affectuate and transform each other. The Harvard Mark series of electromechanical computers designed by Grace Hopper and Howard Aitken during the 1940s are useful examples to consider in this regard as they were in-effect hybrid machines that operated according to both analogue and digital principles. Controlled by a pre-punched paper tape containing a maximum of eight instructions per tape, the machine performed a series of numeric binary-based calculations. Its digital data was stored and counted mechanically using 3000 decimal storage wheels, 1400 rotary dial switches, and 500 miles of wire. Although its electromagnetic relays classified the machine as a relay computer, all output was displayed on an elec-

46. Greco, 'On the Vitality of Vitalism'. P. 17.

47. Michel Foucault, 'Introduction', in Georges Canguilhem, *The Normal and the Pathological*, New York, Zone Books, 1989. P. 18.

tric typewriter. Brian Massumi in his article "On the Superiority of the Analog" argues that we need to think the analogue and digital together as a 'process of co-operation' engaged in continuous self-variation but not necessarily as one of symmetrical relations. Referring specifically to the digital processing of sounds, Massumi contends that sound waves, which detour in and out of today's digital machines, are always perceptually experienced by the body in analogue form. Sonic vibrations move across our epidermal surfaces and enter into the body as an acoustic continuum, even when the frequency of the sounds produced are those that register beyond the capacity of human hearing (20 to 20,000 hertz). Sound is never experienced digitally as discrete points of static articulation but washes over us in continuous affective movement. '*The processing may be digital—but the analog is the process*'.[48]

> 'The paths of their co-operation—transformative integration, translation, and relay—are themselves analog operations. There is always an excess of the analog over the digital, because it perceptually fringes, synesthetically dopplers, umbilically backgrounds, and insensibly recedes to a virtual center immanent at every point along the path—all in the same contortionist motion. It is most twisted. The analog and the digital must be thought together, asymmetrically.'[49]

The perceived alliance of the digital with vitality seems even more problematic when considered in light of Massumi's argument since the digital, at the level of its technical organization, is determined by a series of static points or co-ordinates along a syntagmatic axis rather than flows of continuous informatic transfer. The extraordinarily high processing rates enabled by digital machines, creates the illusion of continuity through their hyperbolic interpolative powers. Filling in the gaps between each digital threshold masks their actual mode of operation, which is merely an oscillation between on/off states. Within this paradigm, it would seem more appropriate to assign the analogue with its implicit modality of incessant flow to vitalism rather than to mechanism where it is habitually located. Yet in either case this would be a misguided gesture, as Massumi makes clear in insisting that both need to be thought together. Rather than separating these terms, as convention would have it, it is more useful to insist upon the involution of the analogue and digital as joint expressions of a complex engagement with a material world. Although the Harvard Mark II was designed to carry out operations according to distinct analogue and digital principles, the presence of the Hopper moth in one of its relays highlights the impossibility of maintaining strict boundary distinctions between either analogue and digital processes or mechanism and vitalism as each element and event affects and modulates all other aspects of the machine, creating an interpenetrating network of proliferating relationships. As a process of continual unfolding the Harvard Mark II maintains its evolutionary momentum connecting its past to an uncertain future even as it is momentarily waylaid within the pages of this text.

'Mechanist conceptions of the machine empty it of everything that would enable it

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48. "On the Superiority of the Analog", in Brian Massumi, *Parables for the Virtual: Movement, Affect, Sensation*, Durham, Duke University Press, 2002. P. 142.

49. Ibid. P. 142.

to avoid a simple construction *partes extra partes*. Vitalist conceptions assimilate the machine to living beings: unless it is living beings that are assimilated to the machines.'[50] Taking our signal from Canguilhem we will conceive of *both* mechanism and vitalism as making *ethical demands* upon our methodology as researchers engaged in listening to the complex testimonials of our objects as they come into machinic being. The concepts of mechanism and vitalism are clearly sites of ongoing contestation but also spaces of potential renewal for media studies and as such function as creative points of passage between multiple ordering systems which are themselves relational and contingent to each other. The [machinic] assemblage is not opposed to either mechanical machines or organic bodies but is a space of liquidity and confluence where machines and bodies interact and coalesce.

'Every machine, [say Deleuze & Guattari] in the first place, is related to a continual material flow. . . that it cuts into. . . every machine functions as a break in the flow in relation to the machine to which it is connected, but at the same time is also a flow itself, or the production of a flow, in relation to the machine connected to it.'[51]

PART VIII

James Gimzewski and Victoria Vesna in their article "The Nanomeme Syndrome: Blurring of Fact and Fiction in the Construction of a New Science" state that the shift in nanotechnology away from what is seen towards what is sensed, constitutes a fundamental break with the ocular regimes that have dominated western technologies of surveillance and observation up until now. Moreover, they argue that such a transition cannot find its conceptual resources in the paradigms of the past. Nanotechnology's radical approach to microscopy they argue demands that powerful new motifs for describing these processes need to be invented. Gimzewski and Vesna feel that such inspiration should come from biology not the retrograde world of mechanics associated with the Industrial Revolution.[52] Their position echoes earlier conceptions of the mechanistic as both reductive and pejorative in that they oppose mechanism with its connotations of construction and engineering to the vitality of living systems, which are characterized as dynamic, open to processes of evolutionary change and mutation. What is at stake in insisting upon the strict separation between mechanist and vitalist models to describe the technologies of material manipulation? In a recent article on nanotechnology N. Katherine Hayles argues that there are hundreds of examples where biological processes are described in mechanical terms.[53] Part of the ambiguity she claims results from a 'fuzzy boundary' between literal description and metaphoric

50. Félix Guattari, *Chaosmosis: An Ethico-Aesthetic Paradigm*, trans. Paul Bains and Julian Prefanis, Sydney, Power Publications, 1995. P. 33.

51. Deleuze and Guattari, *Anti-Oedipus: Capitalism and Schizophrenia*. P. 36.

52. James Gimzewski and Victoria Vesna, 'The Nanomeme Syndrome: Blurring of Fact and Fiction in the Construction of a New Science', *Technoetic Arts Journal*, vol. 1, no. 1, 2003, pp. 7-24. P. 7.

53. N. Katherine Hayles, "Connecting the Quantum Dots: Nanoscience and Culture," in N. Katherine Hayles (ed.), *Nanoculture: Implications of the New Technoscience*, Bristol, Intellect Books, 2004.

interpretation. For example 'the mechanism that maintains fluid equilibrium in a cell is commonly referred to as a sodium pump, a mechanical metaphor if not a mechanical actuality.'[54] This observation is important because it begins to extricate us from the dead-end of binary thinking, reminding us that such connotations are only that—nuanced suggestions that rely upon language to write their discursive teleologies. While new inscriptions can signal new subjectivities, these acts of inscription refer to processes of emergence and thus proceed from a materialist substrate that is actual, not symbolic or linguistic in origin.

French philosopher of science Isabelle Stengers maintains that the fundamental question of experimental science is that of relevance, that is, learning to ask the right questions. Experimentation, she writes, is a 'risky process' because it assumes that what occurs in the natural world operates similarly under isolated laboratory conditions. 'This view presupposes that a question relevant under certain experimental conditions will remain relevant and thus can serve as a model for the generalization of that particular worldview's corresponding mode of distinguishing between what is significant and what is insignificant.'[55] By extension, we might say that the competing visions of nanotechnology as an emergent science share a related risk if its development is conceived along unilateral paths of conceptual affiliation. Envisioning nanotechnology according to either a mechanistic or vitalist [biological] model necessitates an ideological turn that must find in favour of certain properties, selecting some as more relevant and disregarding others as insignificant. The model's scientific purchase requires absolute fidelity in order to sustain the authority of its speech acts. We can see how this becomes highly problematic when theoretical distinctions are made which do not necessarily mesh with the actualities of the world where relationships between mechanism and vitalism appears to be much more indiscrete. Rather than imposing limits on the possible fields of representation we should concern ourselves, says Bruno Latour, with understanding *how* the world generates it owns limits.

PART IX

Evolutionary science is concerned by just such a project as it attempts to understand the ways in which ecologies shift and become witnesses to the slow unfolding of history. Stengers maintains that a perception of the world in terms of causality (means and ends) is rejected by Darwinians who are ultimately interested in opened-ended systems and the forces that impel each towards an uncertain future. Even Darwin did not believe that the mechanism of natural selection had any 'progress of purpose' built into it, a controversial notion in a century dedicated to its progressive futurity. The Darwinians 'have not succeeded in explaining living beings, but rather in constituting them as witnesses to history.' They understand living beings as recounting a history, which they themselves will never know in advance, what history their embodied

54. Ibid. P. 12.

55. Isabelle Stengers, *Power and Invention: Situating Science*, trans. Paul Bains, Sandra Buckley, Michael Hardt and Brian Massumi (eds.), Minneapolis, University of Minnesota Press, 1997b. Pp. 6-7.

materiality will ultimately testify to.[56] As in our case the moth will never know which of its many virtual tendencies its own history will ultimately testify to. The fact of Kettlewell's evidence tampering need not concern us, as the peppered moths themselves ultimately confessed to his own misguided ambitions. In a sense his act of perjury was not to falsify his empirical evidence but to perform an act of ventriloquism, in which his moths appeared to lie under oath, lip-syncing not the truth of their own individuation but the exertions of evolutionary science to verify a hypothesis. The moths in question, like Hopper's own fated bug, became witnesses to stories that they had no direct access to. Evolutionary theory acknowledges the ballast that the past provides to the present as it lurches towards an indeterminate future, but it also understands that the future emerges from a state of contingency and is subject to endless variation, all of which make it impossible to script the advances of tomorrow within the past or even present tense.

PART X

Surely Hopper's moth in crucifying itself inside the Harvard Mark II had no idea as to its subsequent resurrection within computing legend. Pulling the moth out from between its relays did not reassert the autonomous agency of the machine and return it to its natural state, but rather testified to the machine's reliance upon and alliance with a networked ecology of relational processes in which culture has become inseparable from nature and techné from the social. This mythic moth is thus implicated not only in the shared historical accounts of the machine which in turn connects lepidoptery with computing and thus vitalism with mechanism, but also links it with evolutionary theory as a mode of understanding how the contingencies of the material world exert pressures that demand the continual re-invention of the world. Such forces whether latent or virtual in the past life of a system do not merely generate its limits but become *the* animating forces in overcoming such limits. The Hopper moth although smothered in its celluloid larvae and permanently sealed within the archives of the Smithsonian is far from mute as evidenced by its enunciatory and networked presence throughout this and other texts. Tracing the trajectory of moths through the computational regime of the machine writes a 'propositional fiction' that extends life beyond the jurisdiction of the biological sciences and reorients the machine towards its relational modality with all other articulating domains. 'It cannot be simply a question of inverting the dualism of machine and organism which has structured the history of metaphysics. Rather, the mapping of machines and organism can be constructed in novel ways to the point where the fixity and certainty of techno-ontological boundaries and disinclinations begin to destabilize and break down in true machinic fashion.'[57] This strategic re-alignment introduces an important narrative element into their shared machined ecology, one that has the capacity to script other versions of events, other histories, out which

56. Isabelle Stengers, *Power and Invention: Situating Science* (Minneapolis: University of Minnesota Press, 2000). P. 171.

57. Keith Ansell Pearson, *Viroid Life* (London: Routledge, 1997). P. 137.

filiations of radical difference might emerge.[58]

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58. See Elizabeth Grosz, *Time Travels: Feminism, Nature, Power* (London: Duke University Press, 2005). P. 23.

pp. 15–27.

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